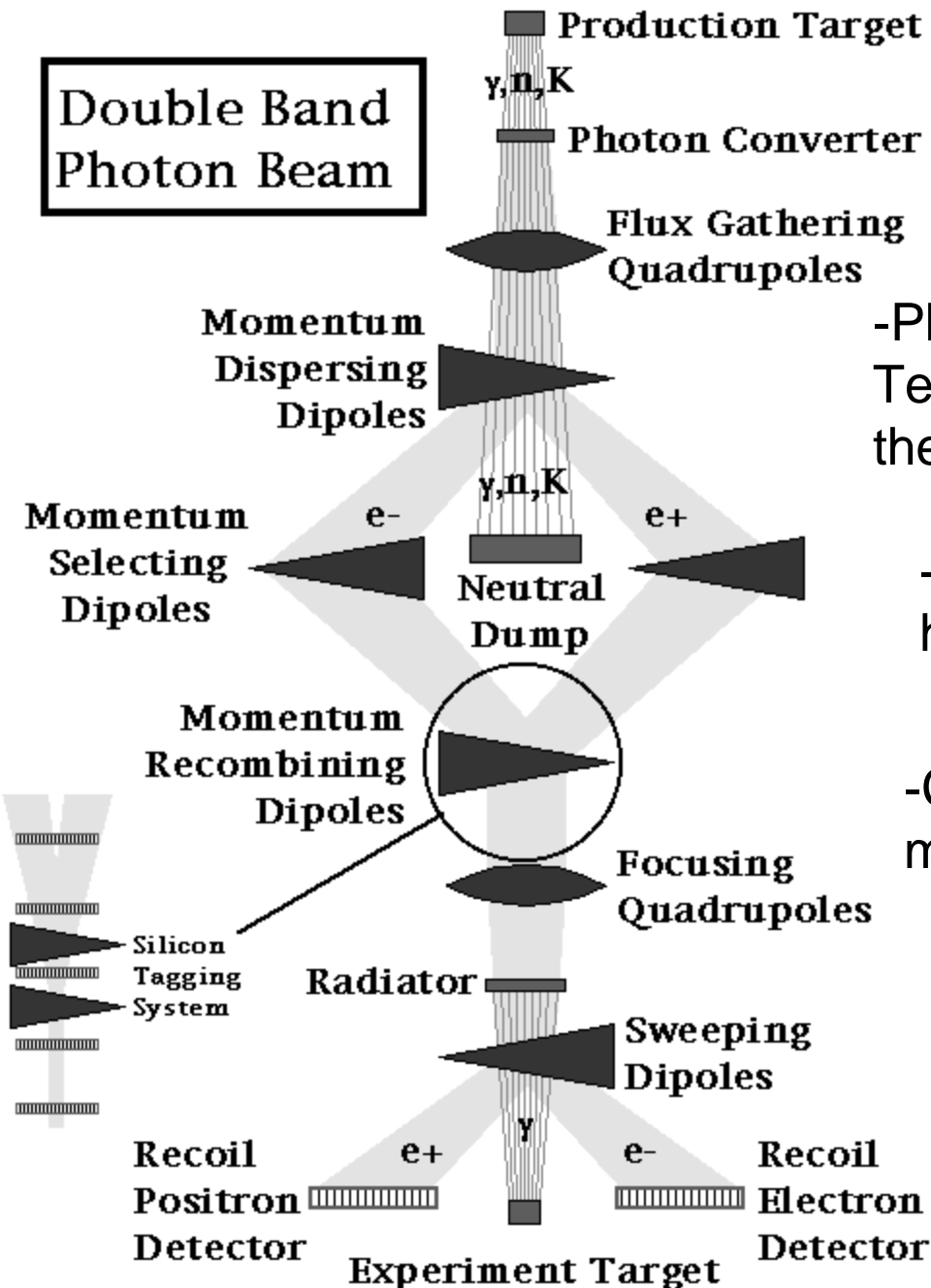


# The case for another run of FOCUS (E831) in retrospect

What might an old FOCUS  
experimenter do now with more  
photons?

## Double Band Photon Beam

## FOCUS: Photoproduction of Charm with an Upgraded Spectrometer\*



-Photons created from the “0.8 Tevatron” (We got 800 GeV protons in the fixed target areas)

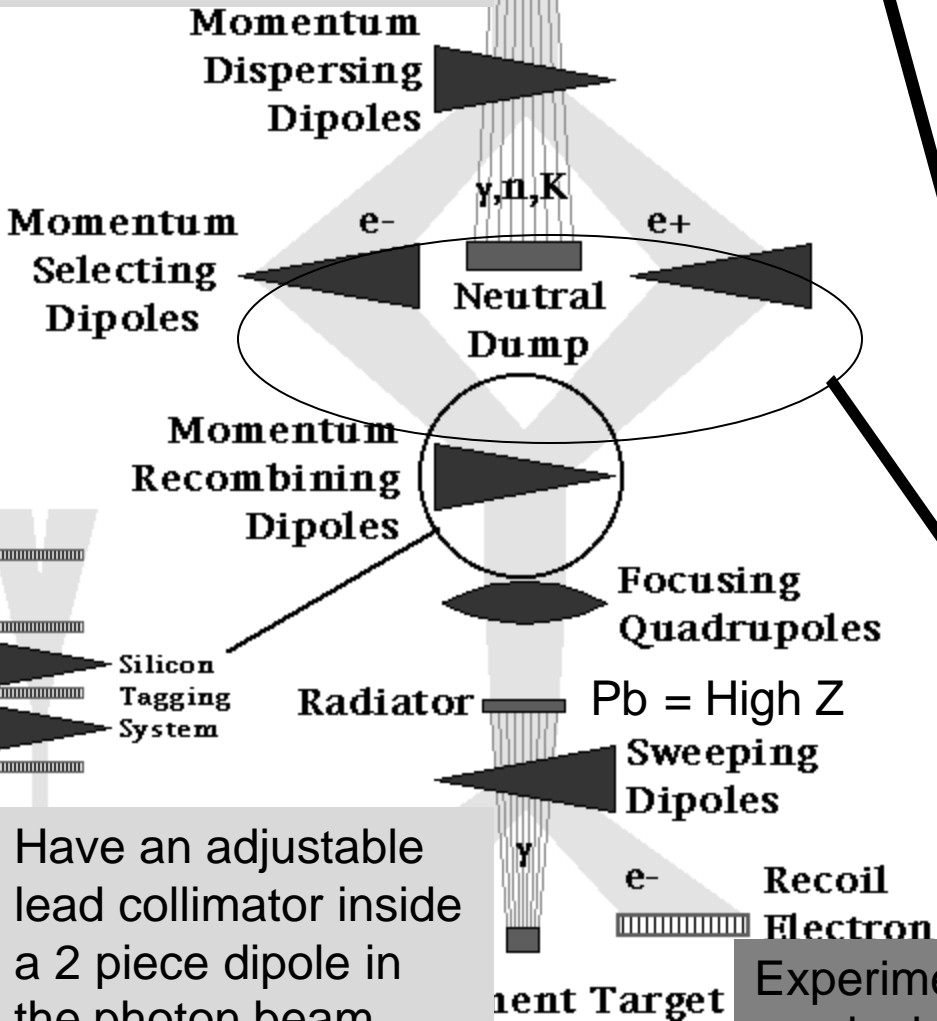
-Reconversion reduced hadron contamination

-Can measure incoming Beam momentum, and “tag” before Brem.

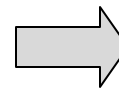
-Versatile beam! Photons, electrons, pions, protons, muons

\* I preferred SPOCK (Some People On a Charm Kick...)

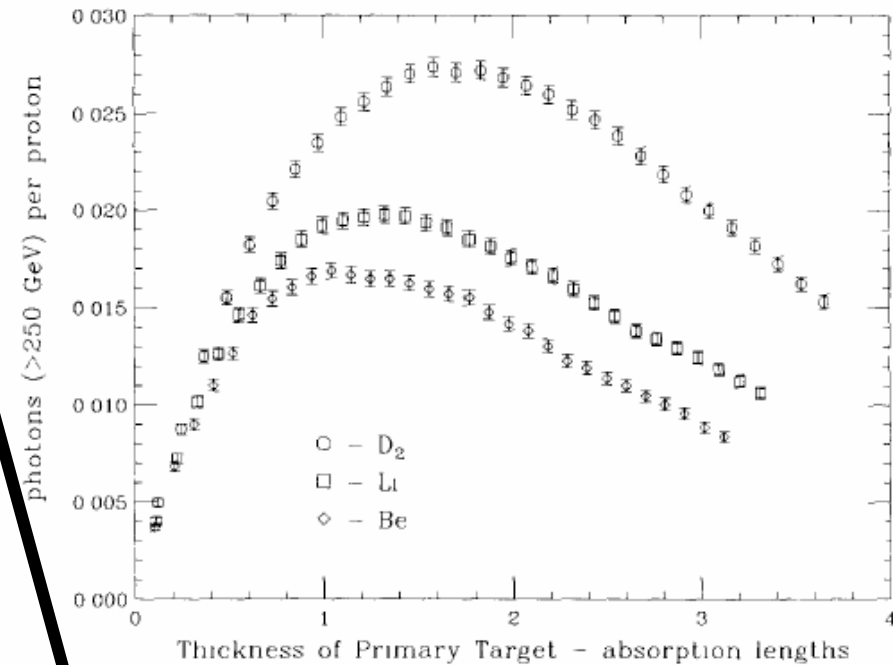
Production target in an active (sweeping) dump. Important to sweep up to, and bend quickly after.



Have an adjustable lead collimator inside a 2 piece dipole in the photon beam.



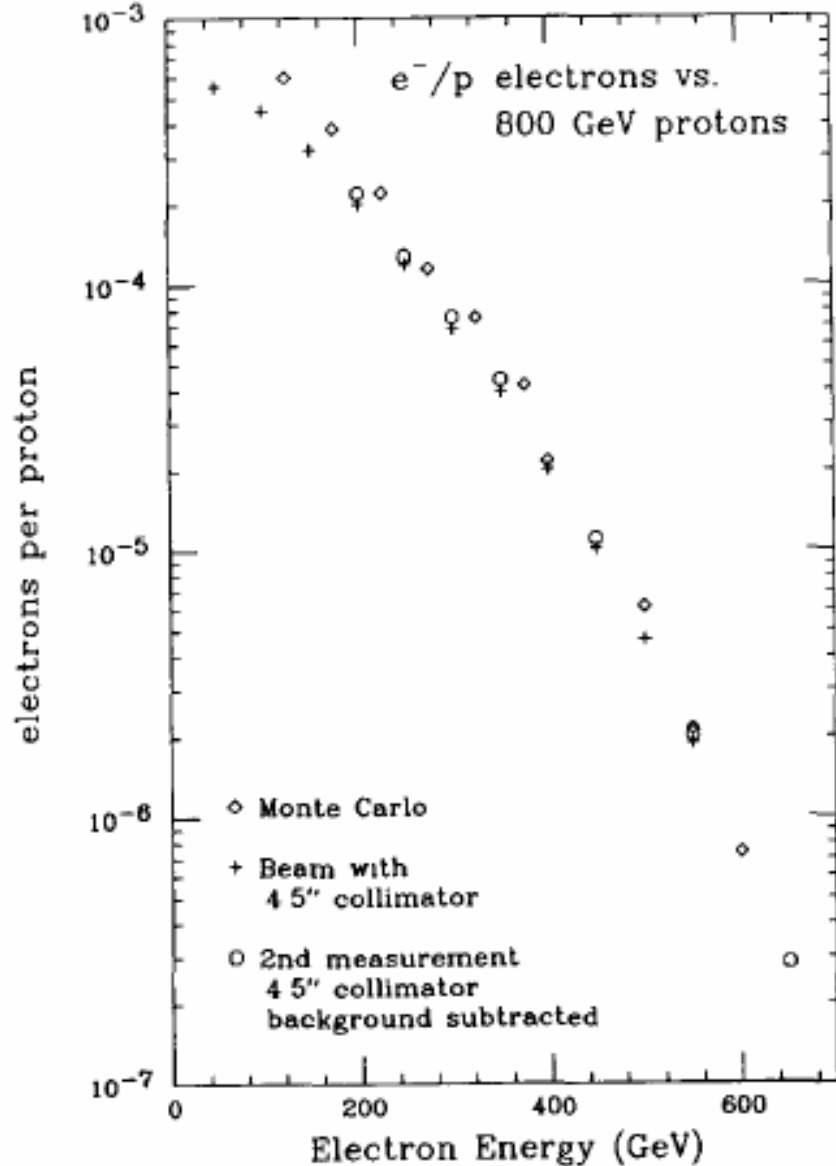
Liquid Deuterium optimized yield of high energy photons:



Uranium 0.6Xo to get more Z/A

Both  $e^+$  and  $e^-$  give  $1.7 \times e^-$ :  
FOCUS used lower energy (250-300 GeV) than E687 (350 GeV) to use  $e^+$  beam.

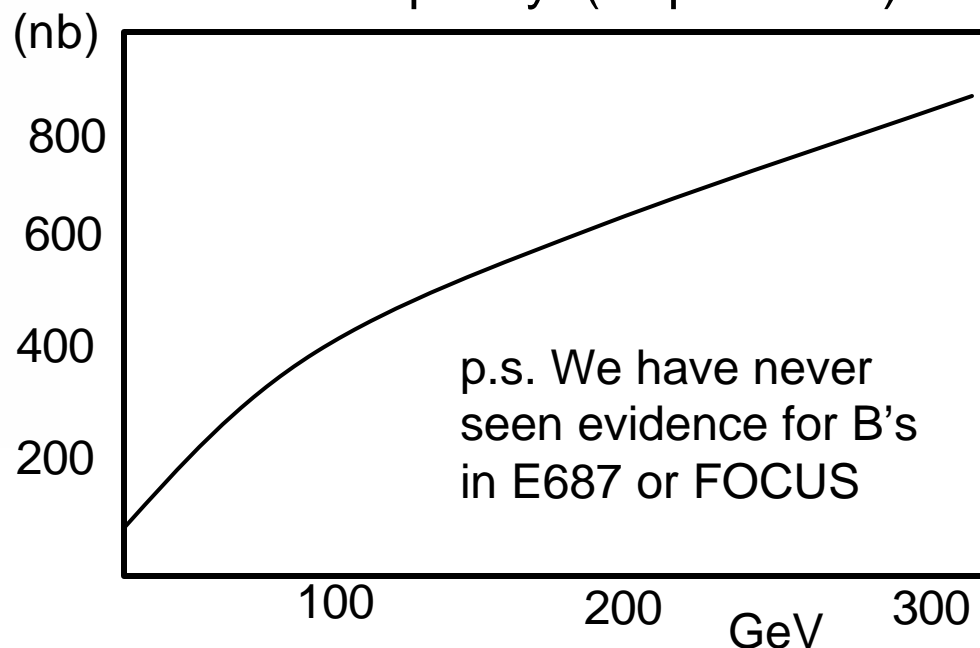
Experimental target is much bigger than nominal beam to help shield vertex detectors from soft photons



Idea was to get more rate!

## Why Lower Energy Photons for FOCUS?

- 1) Photon flux really craps out at higher energies
- 2) Neutral Hadron background has a more persistent harder component
  - i) Worse for  $e^+$  side from Lambda decays
- 3) Charm cross section doesn't fall as quickly: (vs photon E)



# Why photons at all?

- Good: Higher ratio of charm/hadronic interaction for comparable energy hadron beams:
  - $\sim 1/100$  vs  $\sim 1/1000$
  - Pair production easier to filter than hadrons
    - And pions/kaons make muons!
- Good: Events Cleaner (only glue on one side of charm pair = less hadronization, cleaner interaction point)
- Accidentally Good: beam is spread out ( $\sim 1$  cm)
  - Embedded extra pairs likely NOT confused with Charm Vertices
  - Radiation damage effects are spread out
- Bad: Lots of pairs to deal with ( $>10$  MHz)
- Bad: tougher to get high charm rate ( $<1$  Hz)
- Bad: tougher to get higher energy photons

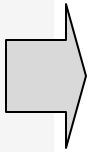
# FOCUS: Triggering Concepts

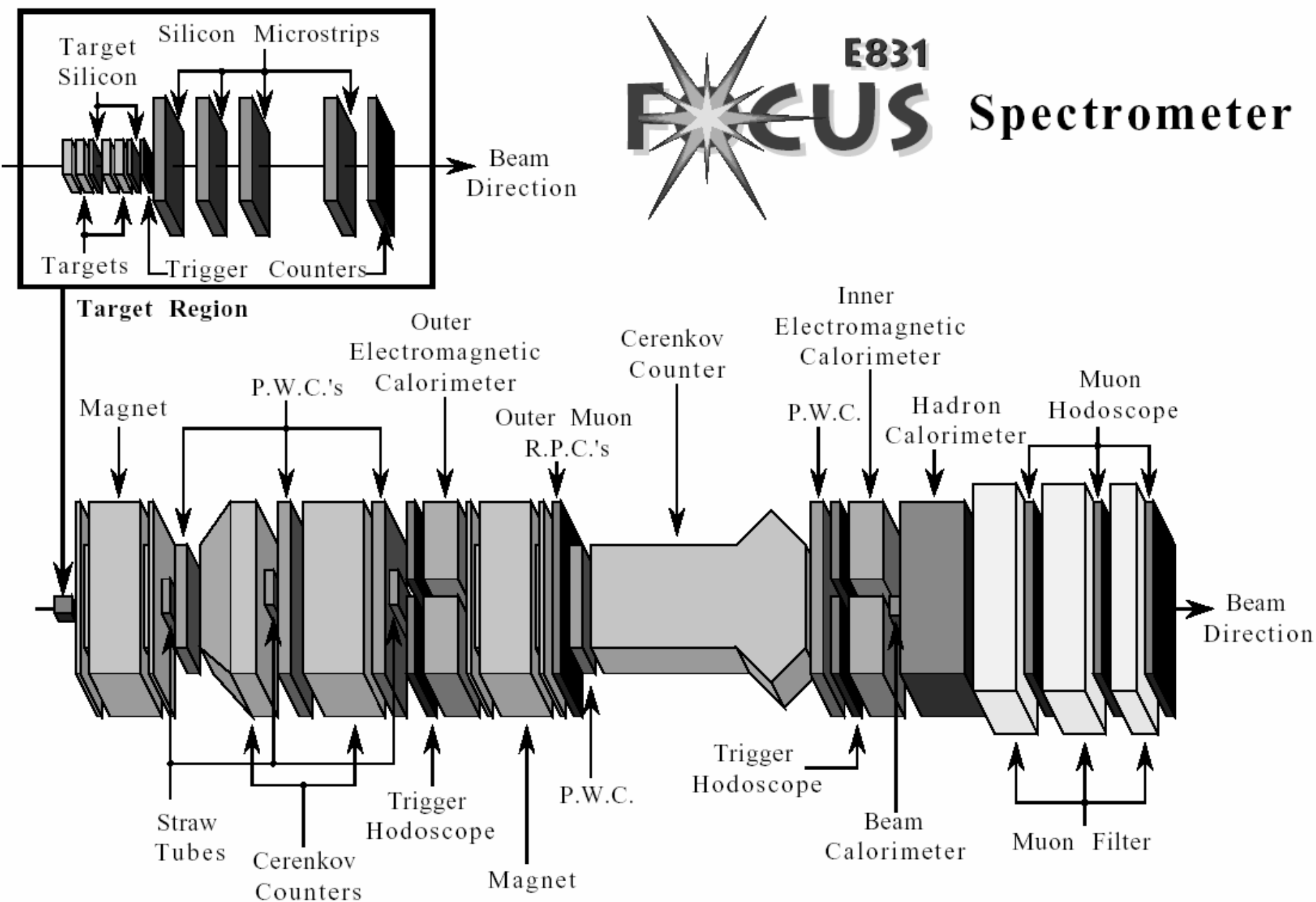
Separates  
e+e- from  
Hadronic



- Make sure charged tracks produced by a photon interacting in the experimental target pass through the vertex detector
  - Tracks that are not in a region you expect from pairs (sweep in a thin swath after magnets)
  - In separated parts of the detector
- When there is  $\sim 35\text{GeV}$  or more energy deposited in the Hadronic trigger OR there were separated hits in muon detectors (muon trigger often needed prescale)
- Slower triggers were refinements

Enhances  
charm that  
CAN be  
reconstructed

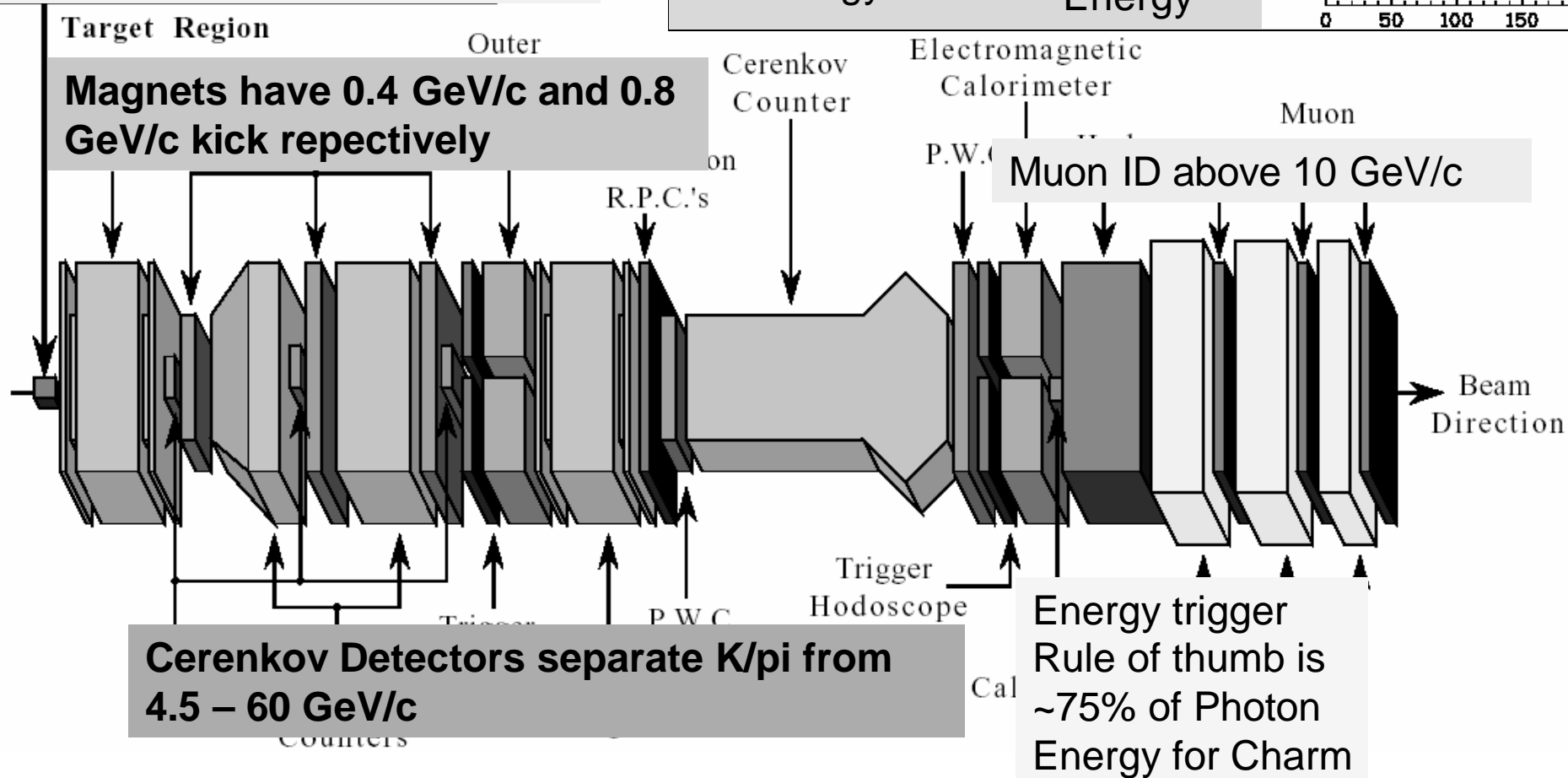
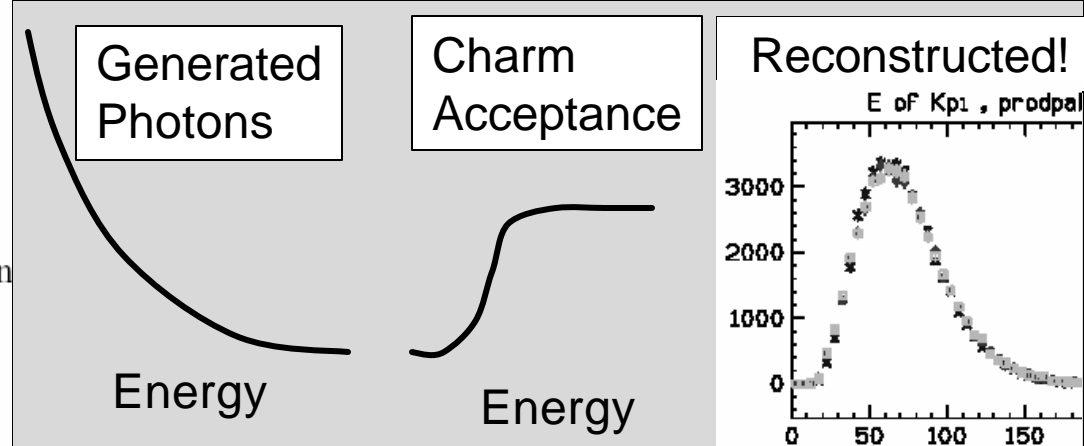




Magnets bend in and out of the page in this view. Notice the Gap for pairs!

Detector imposes acceptances that can be reflected in the trigger. No need to take the lower energy events!

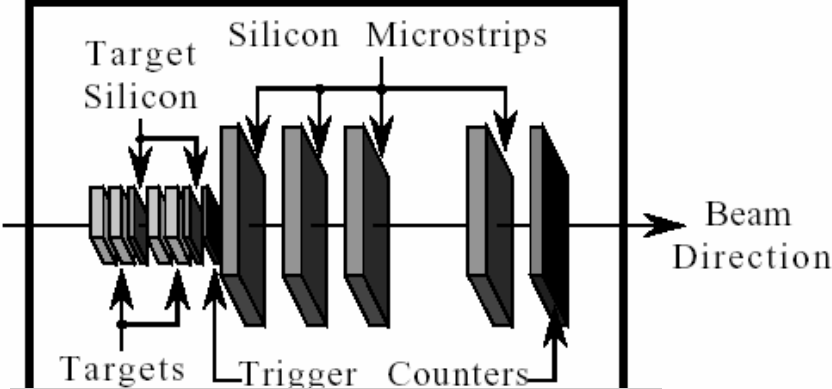
am  
ction



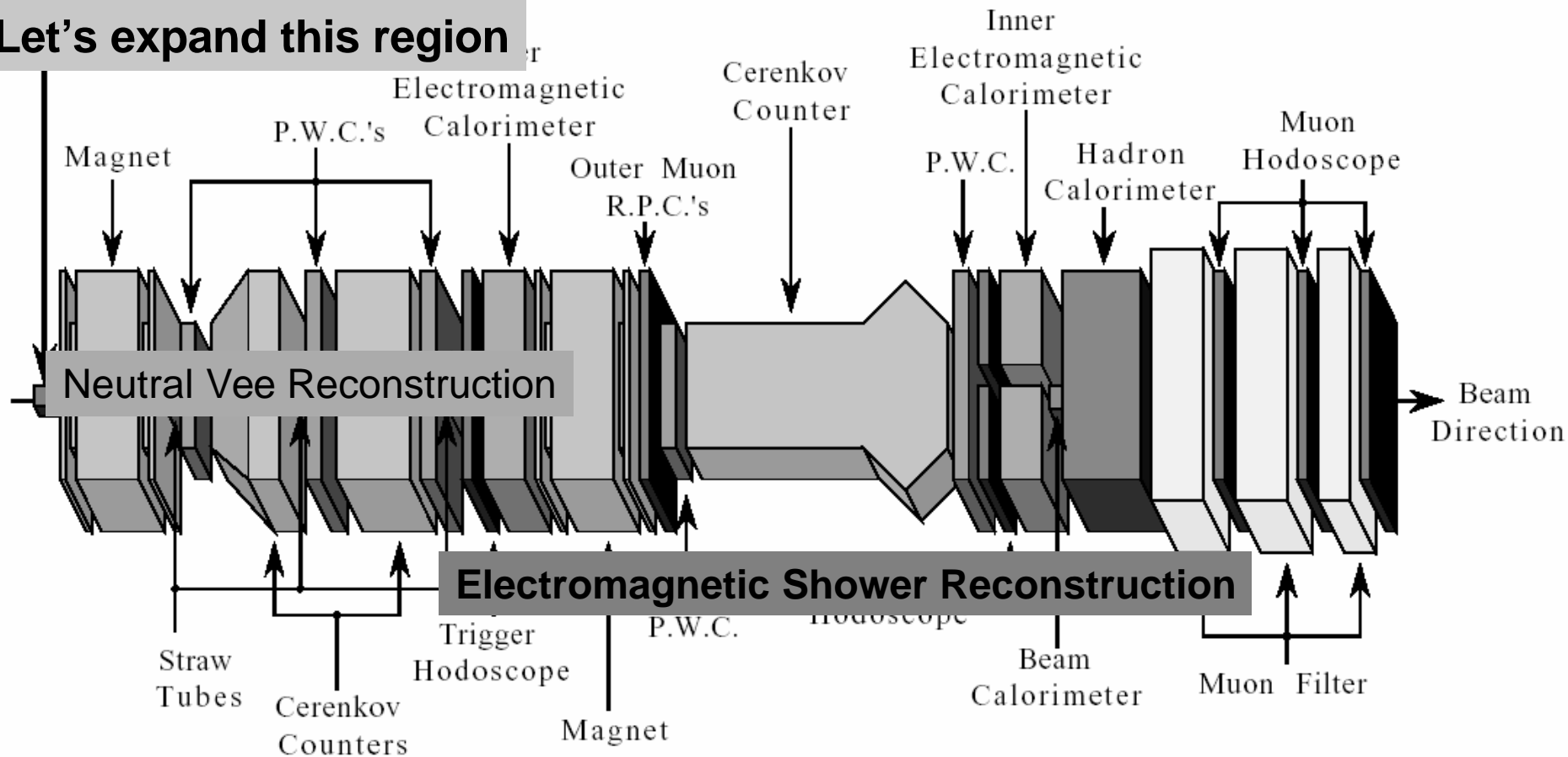


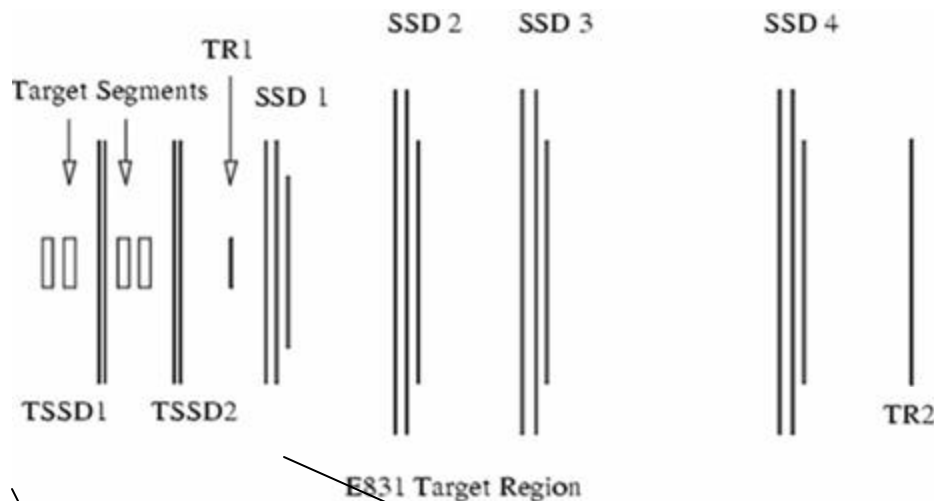


# Spectrometer

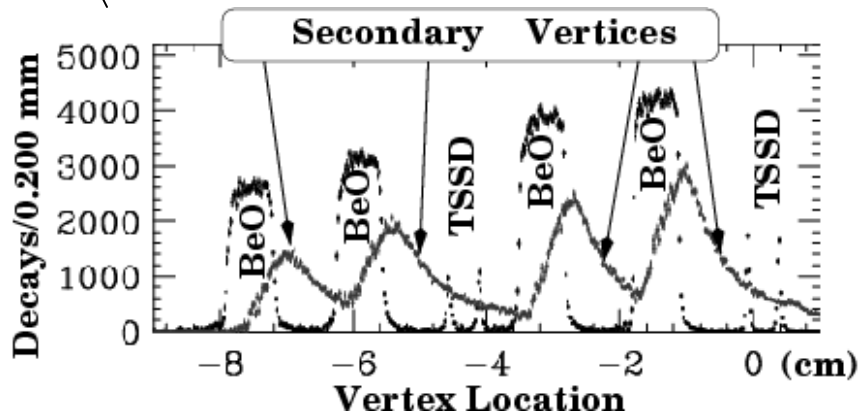
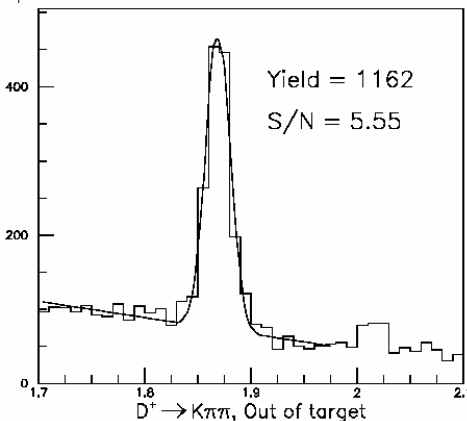
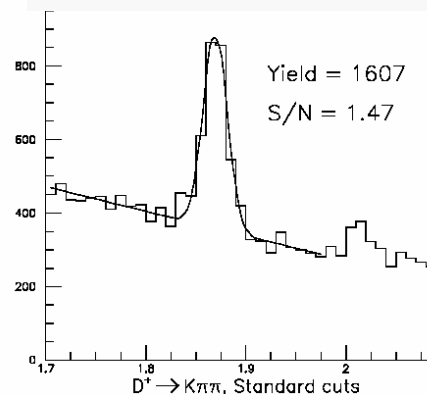


**Let's expand this region**

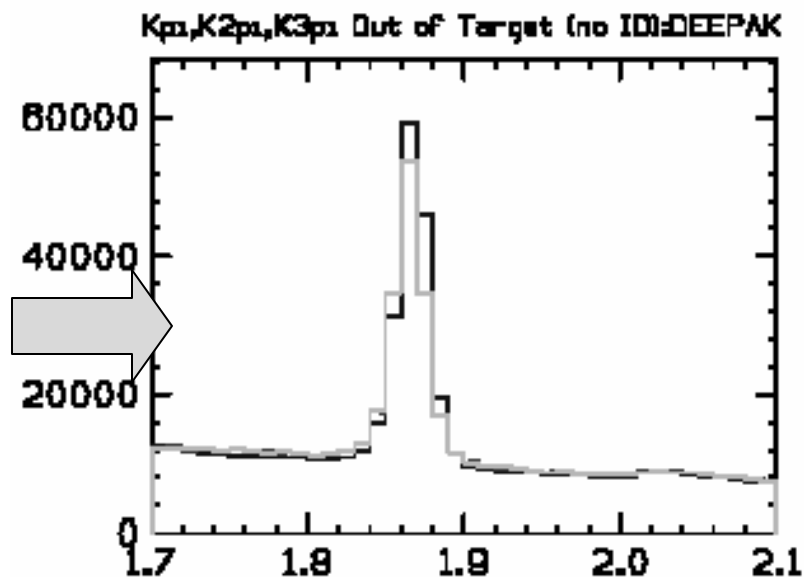




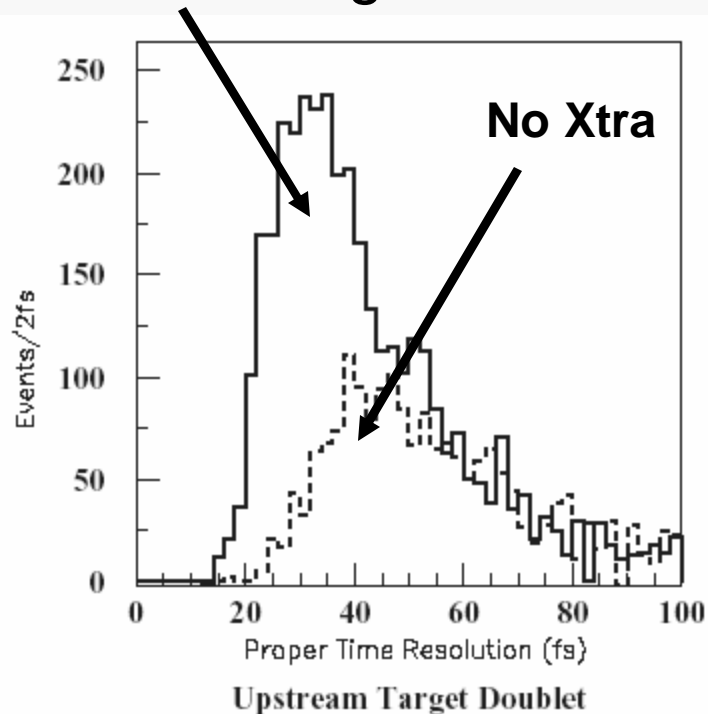
Reconstructing Particle Decays outside of target material is a winner!



After out of target cut, data background dominated by Charm (green is overlay of a quickish simulation which has no min-bias)

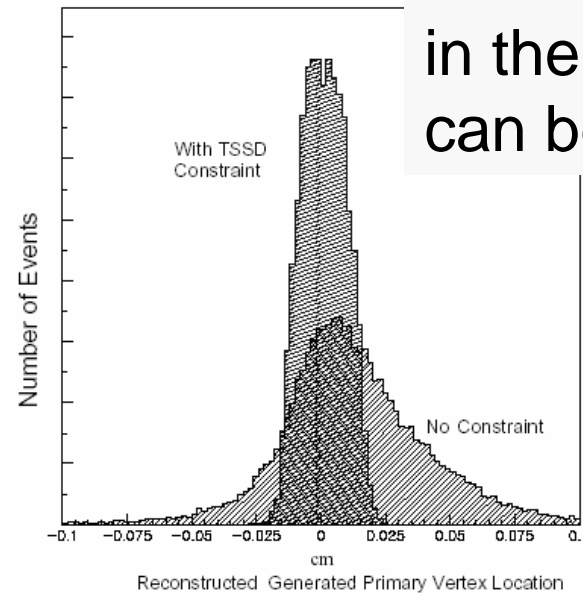


Silicon Plane hits in target region improve resolution, help overcome effects of extended target

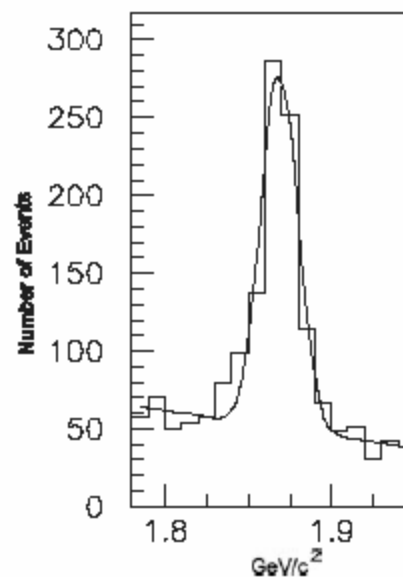


Verifying a D track with Embedded Silicon works too (but lose x10 in stats!)

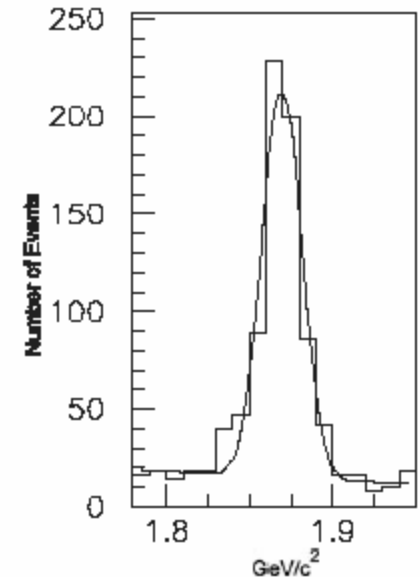
Interaction vertices in the Target Silicon can be constrained.



Target Silicon D tracking



K $\pi\pi$  from skim



K $\pi\pi$  perfect TS track

FOCUS was the best we could do with what we had. Otherwise...

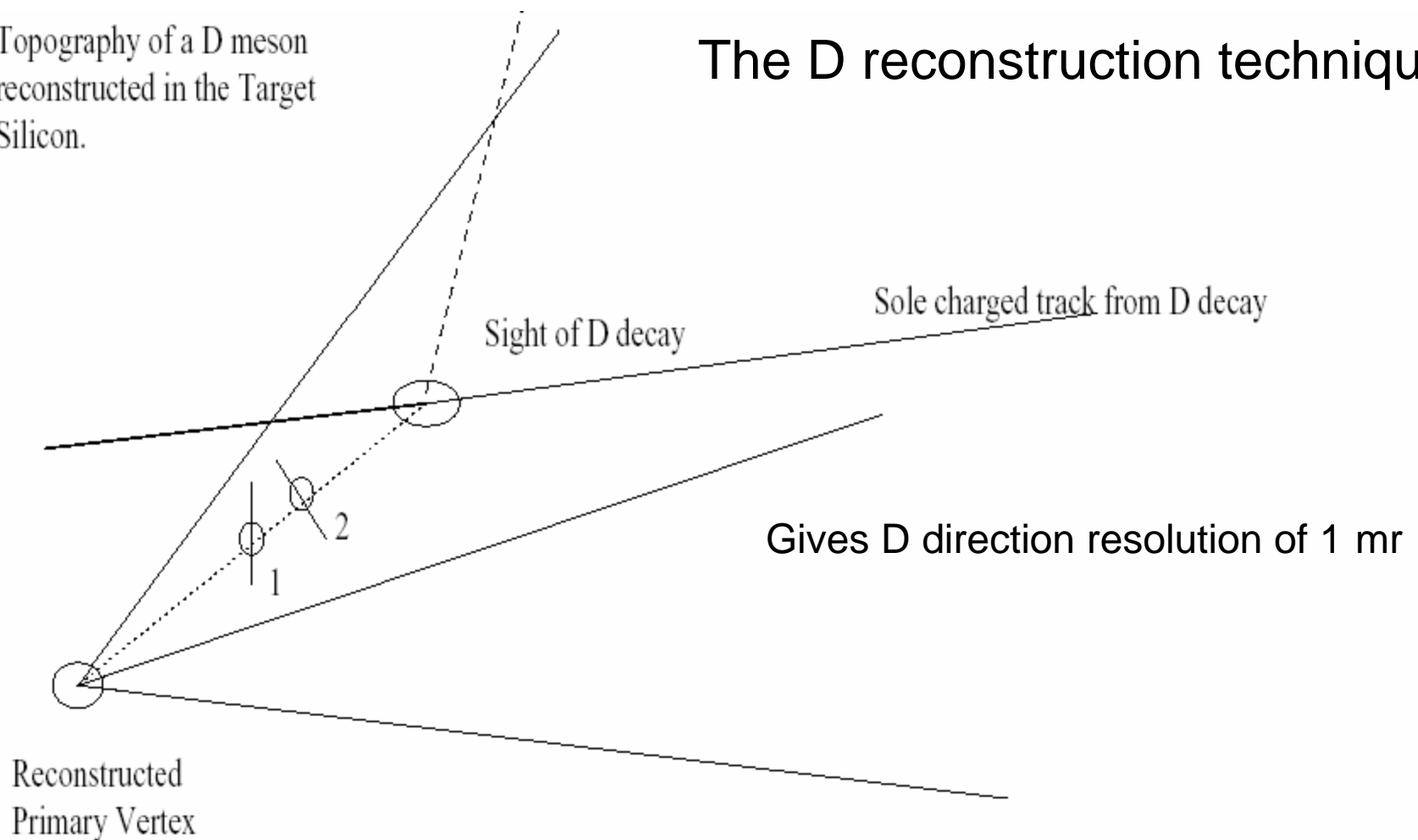
- The target region would have been populated with diamond strip detectors that were both targets and detectors.
- We would have had a finely segmented hadron calorimeter to do neutral hadron reconstruction.
- We would have run longer...

# The Case (then) for an Extension to FOCUS

- Re-arrange the targets to emphasize charged D tracking and measure  $f_D$  via the decay  $D^+ \rightarrow \mathbf{m}^+ \mathbf{n}$
- Replace the PB converter for the final photon beam with a crystal (Coherent Brem)

Topography of a D meson  
reconstructed in the Target  
Silicon.

# The D reconstruction technique

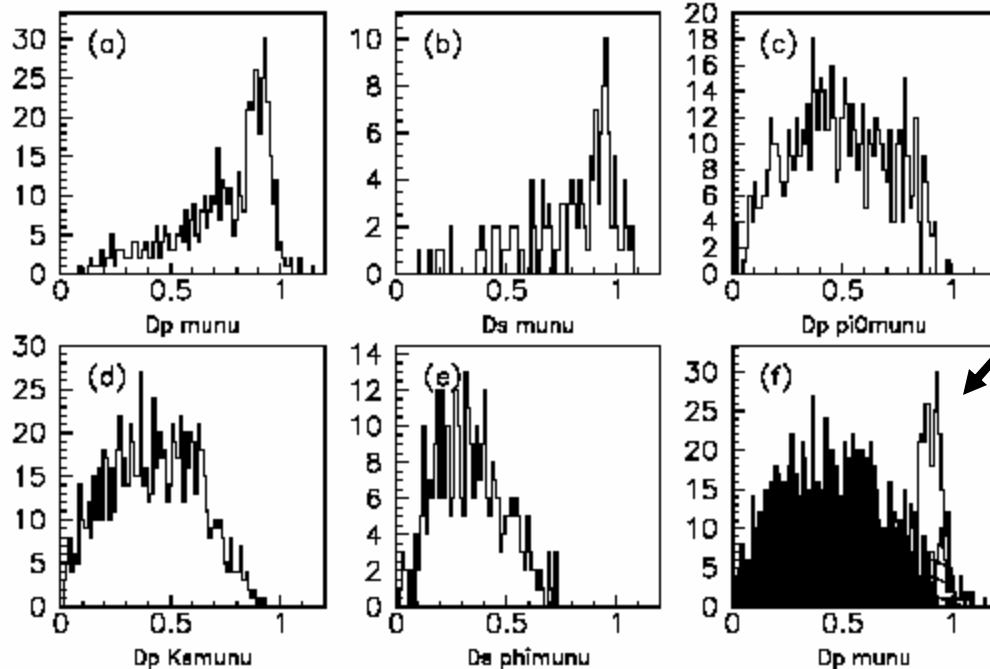


Using the position of the reconstructed Primary vertex and the hits (1 and 2) in the Target

Silicon planes, we can reconstruct the D meson trajectory. We choose the putative D meson

track that forms the best vertex with the sole charged track from the D decay.

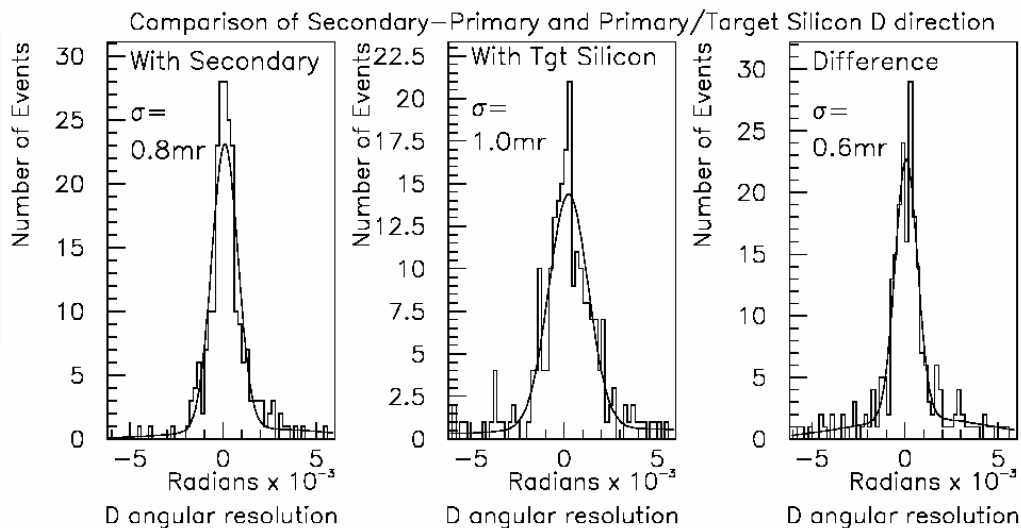
# Muon Transverse Momentum

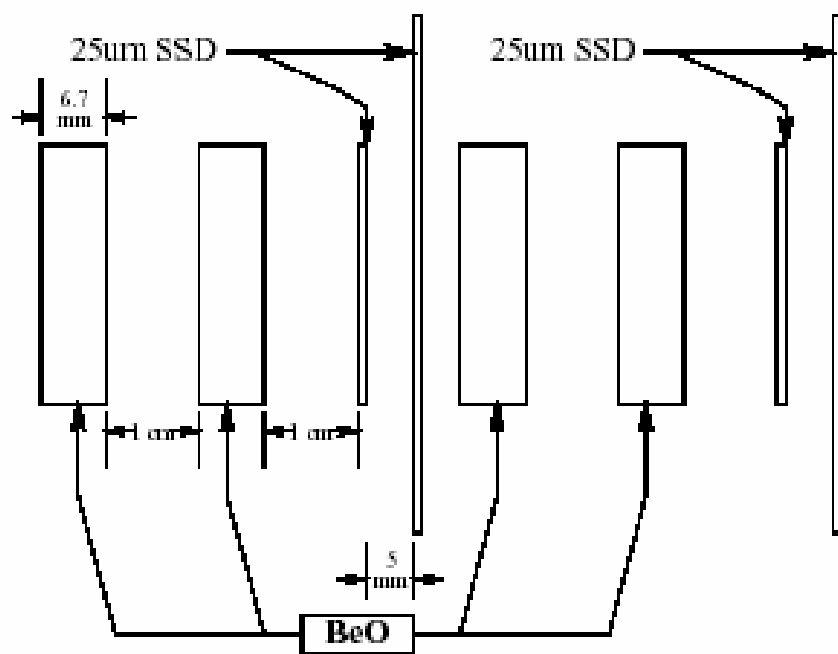


Then we look at the muon transverse momentum

But we felt we could do better with the resolution

Study showing that the D Track resolution in this technique has big contributions from the interaction vertex



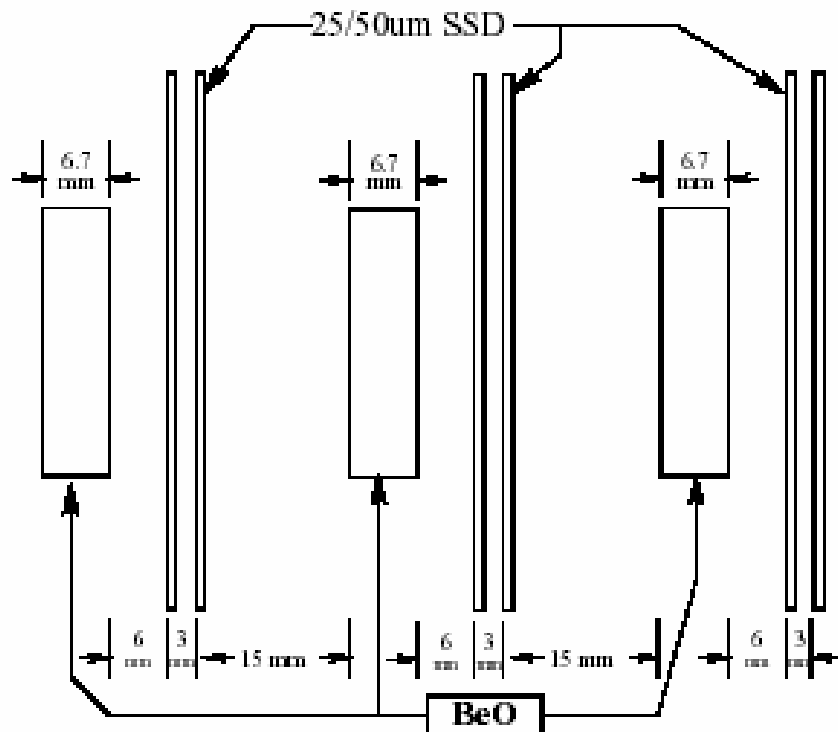


E831/FOCUS Configuration

The bottom diagram is the best we could do given time/money constraints

But keep in mind:

- 1) D tracking is very do-able
- 2) More active tracking improves the resolution
- 3) Thinner target segments allow a constraint



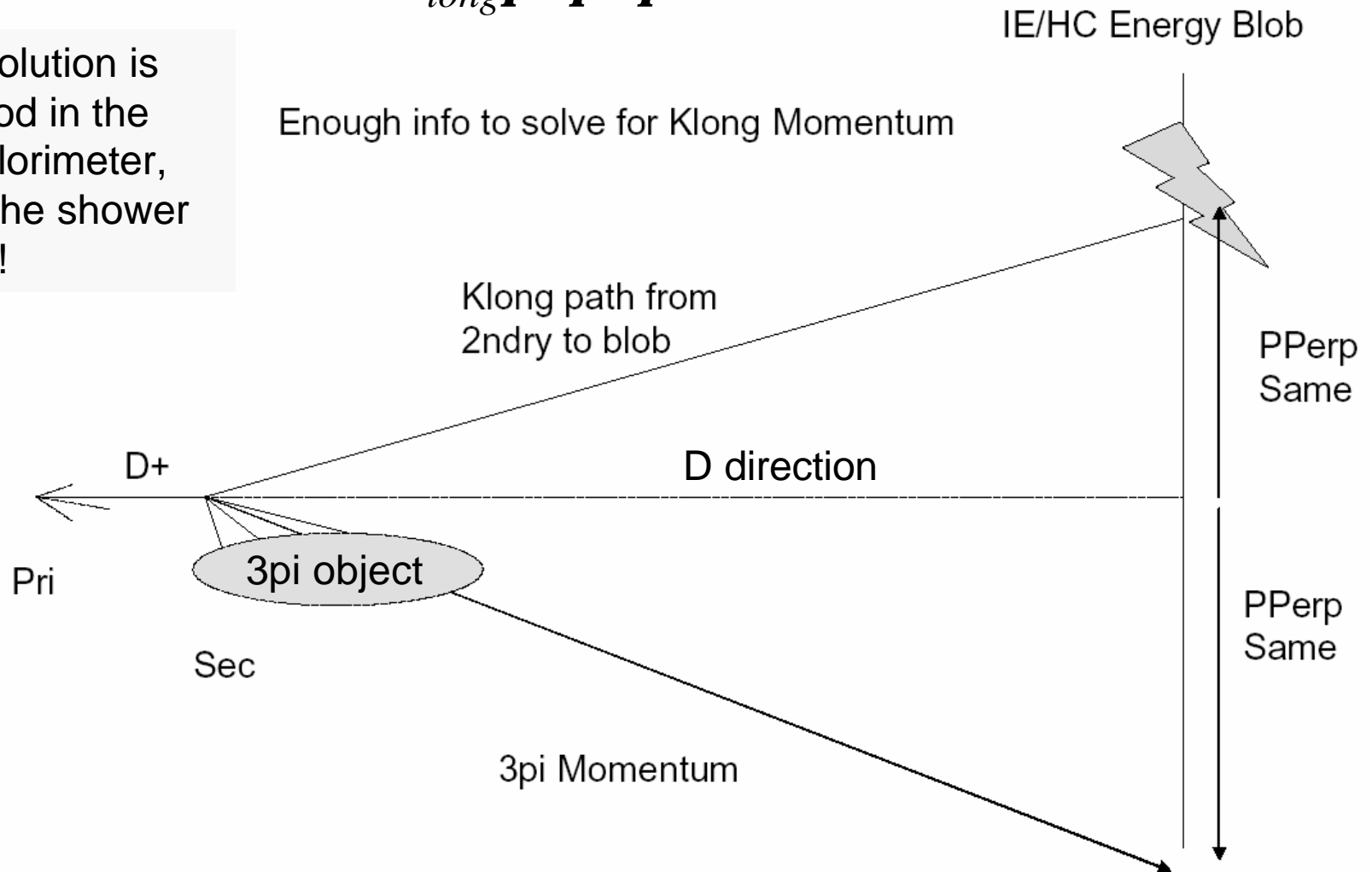
FOCUS Extension Configuration



# So what else is D tracking good for?

How about  $D^+ \rightarrow K_{long}^0 p^+ p^- p^+ !$

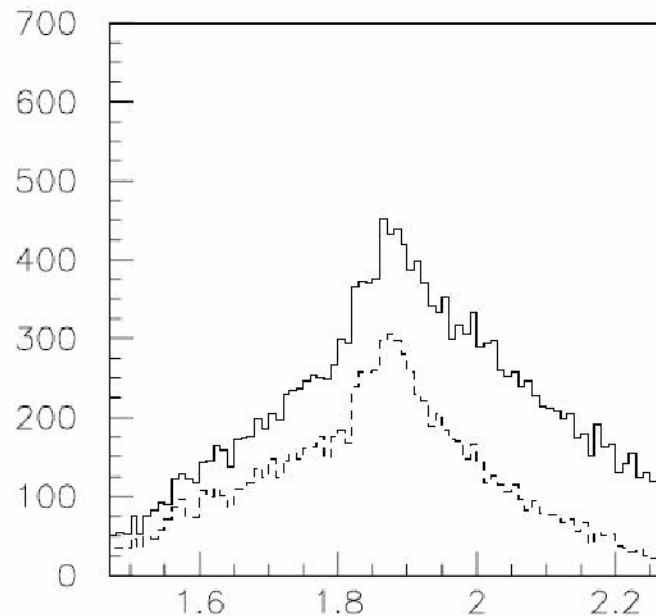
Energy resolution is not real good in the Hadron Calorimeter, but *where* the shower occurred is!



# First Public Showing!

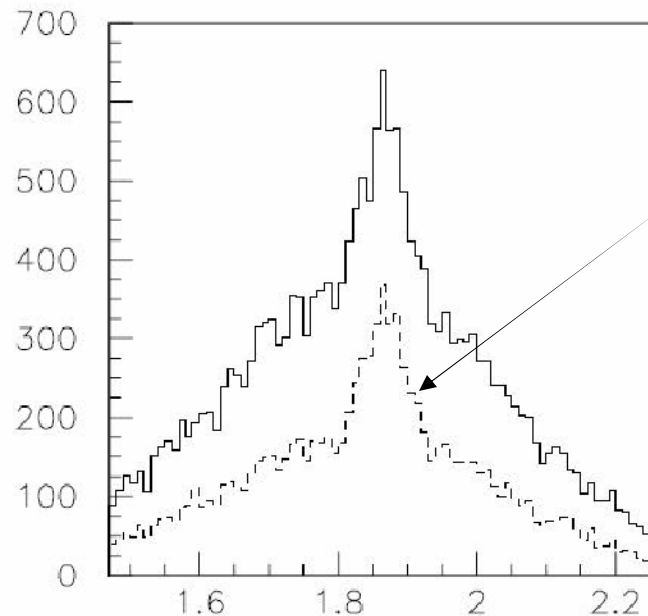
A peek at:  $D^+ \rightarrow K_{long}^0 p^+ p^- p^+$  ! (from a partial FOCUS sample)

Calorimeter Energy only



Total HC

Using Pperp info only



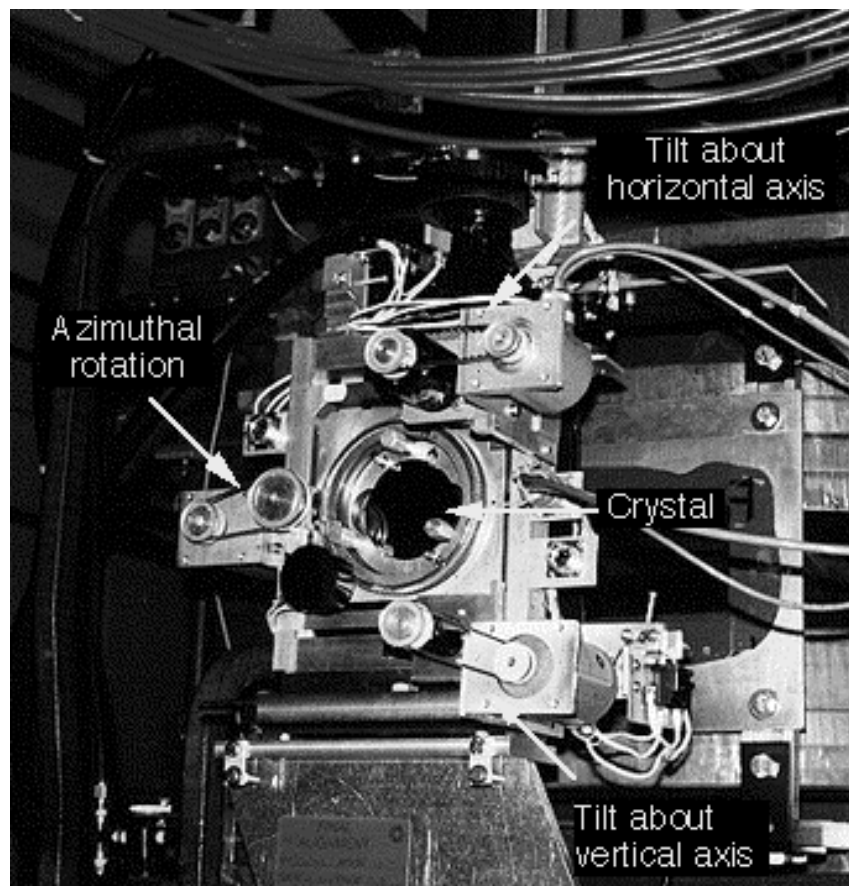
Total Pperp

Tighter Cuts

Can be done for any neutral leaving a position in the calorimetry.  
Again, resolution is dominated by determining the D direction

# Hardening the Photon beam

- One of the last tests we did with the FOCUS spectrometer was to replace the 0.2 Xo Pb radiator with a 1.1 cm Silicon crystal (0.12 Xo)



# Got a lot more Bang for the electron

> 100 GeV in Hadron Calorimeter

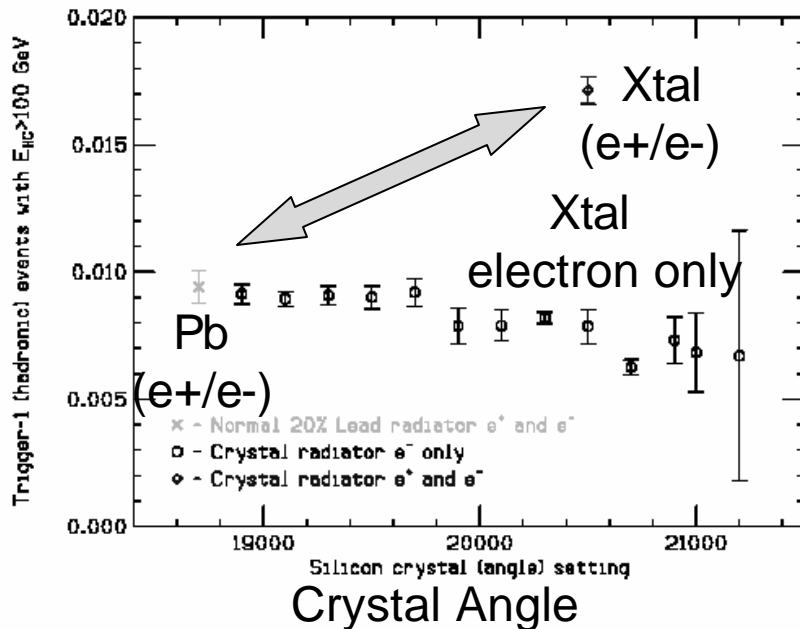


Figure 15: Normalized trigger rates with  $E_{HC} > 100$  GeV

Need a more complete study if there is more interest.

Saw a bigger angular dependence at lower photon energies. Effects more pronounced in beam with less angular spread!

> 30 GeV in Hadron Calorimeter

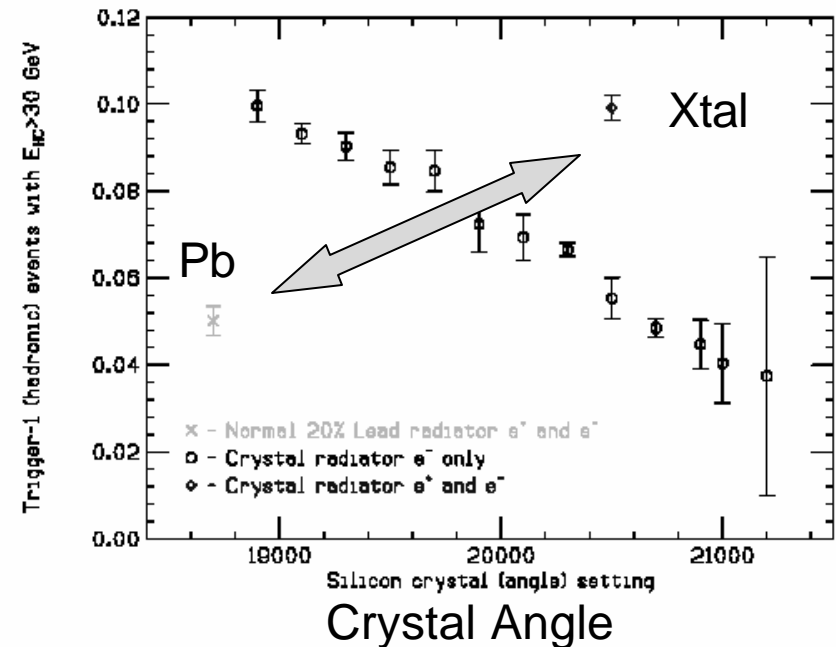


Figure 14: Normalized trigger rates with  $E_{HC} > 30$  GeV

Normalized Hadronic Trigger Rate

# A new FOCUS in retrospect

- What is likely to be left to do beyond cross section measurements in the Post Cleo-c, BaBar, Belle, LHCb era?
  - I claim that what made the FOCUS extension unique was the emphasis on improving the resolution of reconstructed charm, and in particular in reconstructing *D tracks*
  - There is a lot of research now on pixel detectors, (for the ILC in fact!) and the hope for a “digital emulsion” experiment may not be so far fetched anymore. This is where I would concentrate.